FURTHER STUDIES ON OHIO CRAYFISHES. CASES OF SYMPATRY OF STREAM SPECIES IN SOUTHERN OHIO

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The two major stream species of crayfishes in Ohio are *Orconectes propinquus sanborni* (Faxon, 1884), and *Orconectes rusticus rusticus* (Girard, 1852). *Orconectes rusticus rusticus* and its subspecies are widely distributed over the exposed limestones on the flanks of the Cincinnati Anticline and occupy streams in the western half of the state. On the other hand, *O. p. sanborni* seems to have developed in the old Teays River in areas where sandstone and shale predominated. Its present range includes the unglaciated plateau in southern Ohio. Thus, the zone of overlap of these two species forms an irregular north-south band across Ohio. Turner (1926) related this transition zone to the terminal moraine of the Illinoian glacier. In some respects it also closely approximates the easternmost exposures of Niagaran and Devonian limestones. Previous work has not shown just where and how the ranges of these two stream species join or overlap.

While working on bottom organisms in Rocky Fork, Highland County, in 1951, I observed that *O. p. sanborni* was the dominant stream species. During previous fisheries survey work I had found *O. r. rusticus* in most of the adjacent stream systems. It became apparent that somewhere, within a few miles, there occurred a complete change in the crayfish population. This suggested several questions. How abrupt is this transition? What factors are responsible for these changes? If the two stream species should be found together what would be the composition of the resulting population?

METHODS AND MATERIALS

Crayfish were collected from nearly 2,000 localities in southwestern Ohio between 1931 and 1959. These were plotted by species on county maps. A study of these records indicated that the transition from one species to the other occurred at points where major streams cut through the Niagaran escarpment. The following is a list of such streams that nick the escarpment:

1. Rapids in Seven Mile Creek at Eaton, Preble County.
2. Ludlow Falls in Ludlow Creek, Miami County.
3. Narrows in the Mad River at Springfield, Clark County.
4. Clifton Gorge on the Little Miami, Greene County.
5. Devil's Den in Lees Creek, Highland County.
6. Fallsville on Clear Creek, Highland County.
7. Gorges in Rocky Fork and Paint Creek, Seven Caves, Highland County.

The distribution maps indicated that no change in the crayfish fauna occurred at the first five localities. Additional collecting verified that *O. r. rusticus* existed in pure populations above and below these areas. However, the series of collections from the Clear Creek-Rocky Fork system and from Paint Creek and the lower Scioto River contained both species of crayfish. This material was analyzed in detail to determine the percentage of each species in each collection. These results for the critical areas of sympatry are described and tabulated below.

DESCRIPTION OF LOCALITY STUDIED

The main escarpment in southern Ohio is produced by the massive strata of the upper Niagaran limestones. These were turned up by the lifting of the Cincinnati Arch whose main axis extends across Ohio from Cincinnati to the

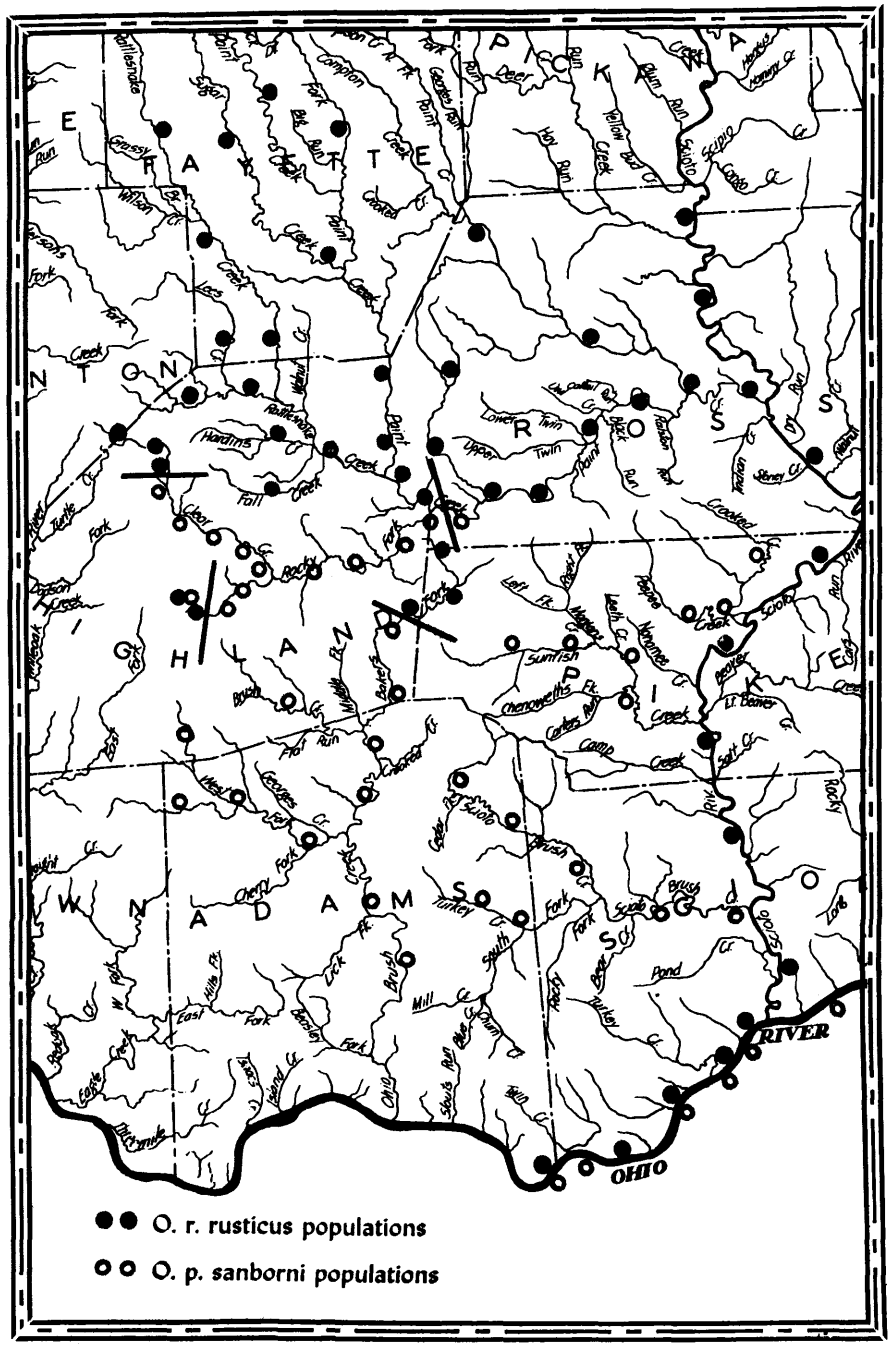

FIGURE 1. Section of southern Ohio showing the distribution of the two dominant stream species of Crayfishes. The ——— marks indicate the general position of the Niagaran Escarpment in major streams under consideration.

Lake Erie Islands. The entire rock structure of southern Ohio dips eastward at the rate of eight inches to one foot per mile.

Streams of the area (fig. 1) generally originate on the limestone uplands and cut down into the thick soft Crab Orchard shales. As they continue eastward and southward they cut through the limestone again before they flow into the region of the black Ohio shale.

The terminal moraine of the Illinoian glacier crosses western Ross County, southeastern Highland County and passes southwestward to the Ohio River (Hyde, 1921). The valleys to the north and west have been filled with debris from local limestone sources. Beyond the terminal moraine, streams of meltwater built up outwash plains and gravel terraces in the valleys which had been a part of the Teays drainage pattern. This filled material is very deep in the North Fork of Paint Creek, and in the lower Scioto valley exceeds 300 ft in places.

As the glacier advanced, Paint Creek was dammed at Slate Mills. This impoundment was increased by charges of glacial water until the water broke through the southern rim, and subsequent erosion of this break cut the "Narrows of Paint Creek." This flooding, discussed later, may have been responsible for extending the range of *O. p. sanborni* beyond the supposed limits of the preglacial Teays valley (Hyde, 1921).

DATA AND DISCUSSION

Analysis of the Crayfish fauna of Clear Creek, Rocky Fork, and lower Paint Creek

Clear Creek, in descending the escarpment at Fallsville, 5 miles northwest of Hillsboro, plunges over two 15-foot cliffs of rock. Below this point the stream has a low gradient and the bottom is sand and gravel.

TABLE 1

Population in Clear Creek at Fallsville, Highland County, Ohio

Locality	*rusticus*		*sanborni*	
	No.	%	No.	%
Above Auburn Chapel	311	100.0		
Immediately above Fallsville Falls	221	100.0		
Falls to 300 ft downstream	144	87.8	20	12.2
300 to 600 ft downstream	124	68.8	56	31.2
600 to 900 ft downstream	52	59.7	35	40.3
900 to 1200 ft downstream	134	46.8	152	53.2
First Road beyond Fallsville	23	4.7	468	95.3
Careytown Rd. (approx. 3 miles downstream)			431	100.0

The headwaters of Clear Creek in western Penn township, Highland County, contain a colony of *O. r. rusticus*. Approximately 1 mile of permanent stream above Fallsville is populated by this stream species and burrowing crayfish associates. Immediately below the falls where the stream bed is filled with large blocks of limestone, *O. r. rusticus* is still the dominant species (table 1) but a mile down stream the gorge aspects disappear, the gradient is lower and *O. p. sanborni* is the dominant species. Throughout the remaining course of the stream *O. p. sanborni* is the prevailing crayfish. Permanent tributary streams of Clear Creek harbor the same species.

Rocky Fork rises on the silt loam area southwest of Hillsboro and within ten miles passes down over exposed beds of lower Niagaran rocks.

TABLE 2
Population in Upper Rocky Fork, Highland County, Ohio

Locality	*rusticus*		*sanborni*	
	No.	%	No.	%
Headwaters near Hoaglands	77	63.1	45	36.9
Danville Pike (SR-138)	103	14.7	595	85.3
New Market Pike (USR-68)	42	17.4	199	82.6
Below New Bridge (SR-73)			688	100.0

Headwaters of Rocky Fork in western Liberty township, Highland County, contain both *O. r. rusticus* and *O. p. sanborni*. Within 5 miles, however, the population changes to *O. p. sanborni* entirely (table 2). This contrasts with the Clear Creek situation where transition occurs in about 1 mile.

Orconectes p. sanborni continues to be the prevailing crayfish in Rocky Fork almost to its junction with Paint Creek. The gorge along Rocky Fork at Seven Caves has been produced by the stream cutting through the dipping cliff limestones. Thus, the stream population changes from *O. r. rusticus* to *O. p. sanborni* where Clear Creek and Rocky Fork descend the escarpment and change back from *O. p. sanborni* to *O. r. rusticus* as Rocky Fork and Paint Creek cut through the Niagaran limestones again.

TABLE 3
Populations in lower Rocky Fork and Paint Creek, Highland and Ross counties, Ohio

Locality	*rusticus*		*sanborni*	
	No.	%	No.	%
Barrett's Mill			226	100.0
Gorge opposite Seven Caves	45	19.5	186	80.5
At USR-50 Bridge	137	51.7	128	48.3
Paint Creek, Rapid Forge	63	100.0		

Below the confluence of Rocky Fork and Paint Creek at "The Point," the transition from *O. p. sanborni* to *O. r. rusticus* is rapid. The last mile of Rocky Fork contained only 19.5 percent *O. r. rusticus* (table 3). While at the convergence of the streams 51.7 percent were *O. r. rusticus*. Within a thousand feet there was a decrease of 32.2 percent in *O. p. sanborni*.

Paint Creek, the larger of the two streams, drains a large territory in Highland, Fayette and Madison counties. This is an early Wisconsin drift area where the till is decidedly calcareous. *Orconectes r. rusticus* is the prevailing species in Paint Creek above and below the junction with Rocky Fork while the smaller tributaries harbor populations of *O. p. sanborni* (table 4).

Orconectes r. rusticus extends down the Scioto and Ohio rivers and eventually joins the metropolis of the species in the Cincinnati area. Thus, colonies of *O. p. sanborni* in Clear Creek, Rocky Fork, Pee Pee Creek, Scioto Brush Creek and other small permanent streams in Adams and Scioto counties are completely surrounded by *O. r. rusticus*.

TABLE 4
Populations in Paint Creek and the lower Scioto River, Ross and Pike counties, Ohio

Locality	*rusticus*		*sanborni*	
	No.	%	No.	%
Paint Creek, 1 mile above the Point	199	100.0		
Paint Creek, just above the Point	216	100.0		
Paint Creek, Rapid Forge Gorge	63	100.0		
Paint Creek, SR-41 at Bainbridge	346	100.0		
Buckskin Creek (1000 ft from above loc.)	64	30.3	147	69.7
Paint Creek, USR-50 E of Bainbridge	267	99.2	2	0.8
Paint Creek, 3 miles E of Bourneville	274	100.0		
North Fork, Slate Mills	271	79.7	69	20.3
Paint Creek, ½ mile W Meade Company	161	100.0		
Scioto River, Higby Bridge	335	89.1	41	10.9
Scioto River, USR-35, Piketon	181	87.4	26	12.6

GENERAL DISCUSSION

Conventional means of plotting distribution of species by shading or delimiting with lines imply that a species occurs uniformly within its established range. We now recognize the fact that an aquatic animal would surely be limited to suitable aquatic habitats. Where two different species are limited to two different drainage systems, we may expect the intermittent streams of the divide to represent a gap or hiatus between the species. It is probable that stream crayfishes are absent in a band ten miles wide on the Scioto-Little Miami divide in western Highland County. Within this and other similar high land areas in the southwestern counties, headwater species as *Cambarus bartoni bartoni* (Fabricius, 1798), *Cambarus bartoni laevis* Faxon, 1914, *Cambarus ortmanni* Williamson, 1907, and *Cambarus diogenes diogenes* Girard, 1852, occupy whatever aquatic or semi-aquatic habitats are available.

Though *O. r. rusticus* and *O. p. sanborni* occupy adjoining ranges in Ohio, their distribution limits would more properly be shown by two distinct lines or even a complex pattern of lines. The only points at which the "*rusticus*-zone" would contact or overlap the "*sanborni*-zone" would be in the beds of the larger streams that transgress the general boundaries of the species (fig. 1).

It was first considered that pH might be the significant factor in distribution. The pH was taken at each collection site at least twice monthly during several years of this study, and there seemed to be only a slight correlation between these readings and the change in crayfish fauna. There was only 0.25 difference in pH between the upper and lower limits of the test area at Fallsville on Clear Creek. At the junction of Rocky Fork and Paint Creek there was no difference in the means of a series of readings taken in the test areas. Should pH be a limiting factor we might associate the appearance or disappearance of a species with certain pH ranges. This was not found to be true. Pure populations of *O. p. sanborni* occur in Clear Creek at Fallsville at a pH of 7.1, in Buckskin Creek at 6.2, in Lake White at 6.6 and in the Ohio River at 7.2. Pure populations of *O. r. rusticus* occur at Fallsville at 7.3, Paint Creek at 6.8 and 7.2 and the Ohio River at 7.4. In this connection, I found during my work on the Ohio River that *O. p. sanborni* appears in the river when the pH reaches 7.2 and disappears 130 miles down stream when the pH is 7.4. This does not correlate with figures in smaller streams in southern Ohio.

The characteristic common to all points where the crayfish species change is the

presence of limestone. The mineral content of the water may be a more significant factor than pH even though the two are related. I have data only on the calcium-magnesium content of the Ohio River as furnished by the U.S. Army Engineers. The disappearance of *O. p. sanborni* in the Ohio River and the presence of *O. r. rusticus* in pure populations seems to be associated with the occurrence of the Ordovician limestone and shale in the bed of the Ohio River near Rome, Ohio. Where *O. r. rusticus* exists in the tributary streams the bottom is limestone or calcareous detrital material.

I have mentioned in an earlier report (1949) the tenacity with which Ohio species of crayfish retain preglacial distribution patterns. *Orconectes p. sanborni* is a Teays River species. Its present distribution still conforms generally to the outline of the ancient Teays valley. *Orconectes r. rusticus* was a preglacial species of the "Cincinnati" River. When the Ohio River was formed the barriers between these ancient rivers were broken down, yet crayfish distribution seems to be only slightly modified by the new drainage pattern.

A few changes may be mentioned here. The glacial impoundment of Paint Creek might have produced a continuous habitat for the migration of *O. p. sanborni* up the Rocky Fork-Clear Creek drainage somewhat above the present 900-foot level. This might also explain the small colony of *O. p. sanborni* in the headwaters of Baker's Fork, a tributary of Ohio Brush Creek. Brush Creek, an *O. r. rusticus* stream, may have been one of the "Paint Creek Lake" outlets as it overflowed the "Beech Flats" in northwestern Pike County.

The *O. r. rusticus* colonies in the headwaters of Clear Creek and Rocky Fork may be explained as coming from the west through a marginal lake that formed behind the Cuba moraine, the terminus of the early Wisconsin glacier. Peat deposits at the north end of the Cowans Creek dam in Clinton County indicate that the water in this lake reached the 980-foot level. This would have connected East Fork of Todd's Fork with Clear Creek and East Fork of the Little Miami with Rocky Fork.

The extension of *O. r. rusticus* down the main stream of Paint Creek and the Scioto River is probably a post glacial development. We might expect a progressive subtraction of the *O. r. rusticus* population down stream as erosion of the acid soil mantle from the hills continues, except where these erosion products are mixed with the limestone gravel of the valley floor.

Two pieces of supplementary data may be cited in this connection. During a study of a low pH phase of Lake Alma, Vinton County, in 1949, the mineral residues of *O. p. sanborni* were compared with residues of *O. r. rusticus* from Lees Creek, Highland County. The residue from *O. p. sanborni* collected in the lake in a sandstone-shale area contained 3.8 percent calcium and 4.1 percent magnesium. The *O. r. rusticus* sample from a creek in the limestone area had a calcium-magnesium content of 24.8 percent.

In August 1939, crayfish (*O. r. rusticus*) became so numerous in ponds at the Newtown State Fish Farm that they interfered with feeding. By intensive seining, 100,000 crayfish were removed. To comply with sportmen's requests, these were stocked in Lake White, Pike County. The normal crayfish in Pee Pee Creek and Lake White is *O. p. sanborni*. While operating test nets in the lake two months later, a dozen shore stations were seined and several thousand crayfish examined, yet not one *O. r. rusticus* was found. This does not prove a 100 percent mortality, but it is suggestive. It would seem that some should have been recovered from the protected rubble areas where heavy stockings were made had any survived.

CONCLUSIONS

After plotting numerous crayfish records of *Orconectes rusticus rusticus* and *Orconectes propinquus sanborni* in southern Ohio, it was discovered that certain

streams contained one species in one section of the stream while the other species occurred in another section of the same stream. More detailed study of the stream crayfishes in several critical areas indicated that the crayfish fauna changed completely within a few miles of free flowing stream. Factors of pH and mineral content of the water were investigated and found to have only a slight relationship with these changes. Transition zones tend to be associated with the Niagaran limestone escarpment. *Orconectes p. sanborni* occurs in streams influenced by shale and sandstone. *Orconectes r. rusticus* is an inhabitant of streams with limestone bottoms.

REFERENCES

Army Engineers, U. S. 1947. Mineral analysis and pH readings in the Ohio River. Photostats. 12 p. data for 1946. (From Marietta to Cincinnati.)

Hyde, J. E. 1921. Geology of Camp Sherman Quadrangle. Geol. Surv. Ohio, 4th Ser. 21: 1–190.

Rhoades, R. 1944. Further studies on distribution and taxonomy of Ohio crayfishes, and the description of a new subspecies. Ohio J. Sci. 44: 95–99.

———. 1949. Stream crayfishes in southern Ohio. Ohio Div. Wildlife, Res. Rept. 44: 1–11.

———. 1951. Biological investigations on Lake Alma During a Low pH Phase. Ohio Div. Wildlife, Prog. Rept. 37: 1–15.

Turner, C. L. 1926. The crayfishes of Ohio. Ohio Biol. Surv. 13: 145–195.